Marginal analysis of income mobility effects by income source with an application to the agricultural policy mix

Allanson, Paul

Published in:
Journal of Agricultural Economics

DOI:
10.1111/1477-9552.12274

Publication date:
2019

Marginal analysis of income mobility effects by income source with an application to the agricultural policy mix

Paul Allanson[1]

Abstract

The note makes novel use of a decomposition of the Shorrocks mobility index by income source to identify the impact on farm income mobility of a marginal change in each component of income. An empirical application shows that a revenue-neutral change in the balance of agricultural protection between market-based support and direct payments would not have reduced the variability of relative farm incomes in Scottish agriculture.

Keywords: farm income mobility; decomposition by income source; agricultural policy analysis; Shorrocks mobility index; Scottish agriculture

JEL classifications: D31, D63, Q18

1. Introduction

Income fluctuations are significantly larger at the farm than the sector level, leading to considerable movement of farms within the income distribution (Meuwissen *et al.*, 2008). One consequence of this income mobility is that longer-term inequality is less severe than would be inferred from cross-sectional estimates based on annual data. For example, Allanson *et al.*

[1] Paul Allanson is with the Department of Economic Studies, University of Dundee School of Business, e-mail: p.f.allanson@dundee.ac.uk for correspondence. The author bears sole responsibility for the further analysis and interpretation of the Scottish Farm Accounts Survey data employed in this study.

(2017) reports a 5.7% fall in the Gini coefficient for Scotland if income values are calculated as two-year individual farm averages rather than a single year, with this fall increasing to 12% as the length of the measurement period is extended to include more years. A further corollary is that risk management schemes that spread individual losses over the general farm population should reduce inequality in the short-term relative to the longer-term by reducing idiosyncratic income volatility. Finger and El Benni (2014) identify this inequality reducing property as an additional benefit of the Income Stabilisation Tool introduced in the 2013 Common Agricultural Policy (CAP) reform (European Commission, 2013).

This note investigates the broader conjecture that the historical shift from market-based support towards direct payments in the CAP will have had a similar beneficial effect by insulating farmers from both price and production risk (European Commission, 2008). Tangermann (2011) argues that the shift reduced overall income variability by providing farmers with regular, fixed payments. However, it does not necessarily follow that farm movements within the income distribution also declined as result. Using the example of Scottish agriculture, the note provides the first estimates, to our knowledge, of the possible impact of this change in the agricultural policy mix on farm income mobility. For this purpose, we decompose the Shorrocks (1978) mobility index by income components to identify the impact of a marginal change in each component on relative short-term inequality.

2. Methods

Let y_t denote annual income in year *t*, with mean $\bar{y}_t$, cumulative density function (cdf) $R_t = F_t\left(y\right) = P(y_t \le y)$ and Gini coefficient $G(y_t, R_t) = 2\text{cov}\left(y_t, R_t\right) / \bar{y}_t$. The corresponding Shorrocks index measures the degree of equalisation if the measurement period is extended to T years:

$$M_T = 1 - \frac{G(y_A, R_A)}{\sum_{t=1}^{T} w_t G(y_t, R_t)}; \qquad T \geq 1 \tag{1}$$

where $G(y_A, R_A)$ is the Gini coefficient of average annual income over the T-year period $y_A = \sum_t y_t / T$, with mean $\bar{y}_A$ and relative ranks R_A; and the weights $w_t = \bar{y}_t / T\bar{y}_A$ sum to one by construction. M_T will be close to zero if there is little income mobility and to one if annual inequality is largely due to transitory idiosyncratic income shocks such that $G(y_A, R_A)$ is close to zero.

Further defining income as the sum of a set of components x_{kt} $(k = 1, \ldots, K)$, which will be positive for revenues and negative for costs, then some manipulation yields:

$$\begin{aligned} M_T &= \frac{2\sum_i \sum_t (y_{it} - \bar{y}_A)(R_{it} - R_{iA})}{NT\bar{y}_A \sum_t w_t G(y_t, R_t)} = \frac{\sum_i \sum_t (y_{it} - \bar{y}_A)(R_{it} - R_{iA})}{N \sum_t \operatorname{cov}\left(y_t, R_t\right)} = \frac{\sum_k \sum_i \sum_t (x_{kit} - \bar{x}_{kA})(R_{it} - R_{iA})}{N \sum_t \operatorname{cov}\left(y_t, R_t\right)} \\ &= \sum_{k=1}^{K} \left(\left(\frac{\sum_i \sum_t (x_{kit} - \bar{x}_{kA})(R_{it} - R_{iA})}{N \sum_t \operatorname{cov}\left(x_{kt}, R_t\right)} \right) \left(\frac{\sum_t \operatorname{cov}\left(x_{kt}, R_t\right)}{\sum_t \operatorname{cov}\left(y_t, R_t\right)} \right) \right) \equiv \sum_{k=1}^{K} M_{kT} v_{kT} \end{aligned} \tag{2}$$

where the first equality holds as $G(y_A, R_A) = \sum_t w_t G(y_t, R_t) - 2\sum_i \sum_t (y_{it} - \bar{y}_A)(R_{it} - R_{iA}) / NT\bar{y}_A$ from results in Jones and López Nicolás (2004); y_{it}, x_{kit}, R_{it} and R_{iA} denote observations on farm i $(i = 1, \ldots, N)$; and $\bar{x}_{kA}$ is the T-year average annual mean of x_k. Hence M_T is equal to a weighted sum of component-related income mobility indices $M_{kT} = 1 - \left(CI(x_{kA}, R_A) \big/ \sum_t w_{kt} CI(x_{kt}, R_t) \right)$, where $CI(x_{kt}, R_t)$ and $CI(x_{kA}, R_A)$ are the concentration indices of component k over the year t and T-year income distributions respectively, and $w_{kt} = \bar{x}_{kt} / T\bar{x}_{kA}$.

$M_{kT} = 0$ if there is no linear association between the component and income mobility since the numerator $\sum_i \sum_t (x_{kit} - \bar{x}_{kA})(R_{it} - R_{iA})$ in (2) will equal zero in this case.[2] But, unlike

---

[2] Note that $(R_{it} - R_{iA})$ captures mobility in terms of the deviation between a farm's rank in the period t and T-period income distributions, with $\sum_i \sum_t (R_{it} - R_{iA}) = 0$ by definition.

M_T, M_{kT} can be either positive or negative. In particular, M_{kT} is likely negative for a time-invariant revenue component that is positively associated with income (i.e. similar to CAP direct payments) given that the cdf $R_t = F_t\left(y\right)$ of the typically unimodal farm income distribution will be convex below the mode and concave above it. It follows from Jensen's inequality that the average of the annual income ranks R_{it} of farms with low (high) average incomes will typically be above (below) their *T*-year income rank R_{iA}, which in combination with the positive association between revenue and income will result in a negative value of $\sum_i \sum_t (x_{kit} - \overline{x}_{kA})(R_{it} - R_{iA})$ and hence of M_{kT} (see Allanson *et al.* (2010) for further discussion). The weights v_{kT} equal the shares of the total covariation between year-specific incomes and ranks that are due to each component. These sum to one, since $y_t = \sum_k x_{kt}$, and will typically be positive for revenues and negative for costs.

To investigate how changes in particular components affect mobility, we follow the approach in Lerman and Yitzhaki (1985) and consider a change in each farm's income due to a change in component *k* from x_{kit} to ex_{kit} in all years, where *e* is close to 1. The effect on mobility will approximately equal:

$$\frac{\partial M_T}{\partial e} = \partial \left\{ M_{kT} \frac{\sum_t \operatorname{cov}(\mathrm{e}\, x_{kt}, R_t)}{\sum_t \operatorname{cov}(\mathrm{e}\, x_{kt} + \sum_{j \neq k} x_{jt}, R_t)} + \sum_{j \neq k} M_{jT} \frac{\sum_t \operatorname{cov}(x_{jt}, R_t)}{\sum_t \operatorname{cov}(\mathrm{e}\, x_{kt} + \sum_{j \neq k} x_{jt}, R_t)} \right\} \Big/ \partial e \tag{3}$$

$$\approx M_{kT} v_{kT} \left(1 - v_{kT}\right) - v_{kT} \sum_{j \neq k} M_{jT} v_{jT} = \left(M_{kT} - M_T\right) v_{kT} = \left(\frac{CI(x_{kA}, R_A)}{\sum_t w_{kt} CI(x_{kt}, R_t)} - \frac{G(y_A, R_A)}{\sum_t w_t G(y_t, R_t)} \right) v_{kT}$$

where the derivation relies on the assumption that income ranks, and hence component-related mobility indices, will not be significantly affected by the change (see Yitzhaki and Schechtman, 2013). Hence whether a marginal, equiproportional change in the *k*'th component increases or reduces mobility, and hence short-term relative to longer-term inequality, will depend on the signs of both $\left(M_{kT} - M_T\right)$ and v_{kT}. $\sum_k \left(M_{kT} - M_T\right) v_{kT} = 0$ since multiplying all components by *e* leaves mobility unchanged.

$M_T = 1 - \left(I(y_A) \big/ \sum_t w_t I(y_t) \right)$ is defined for any relative inequality measure $I(y)$. However, many such measures are undefined for negative incomes (Amiel et al., 1996) so the only other well-known ones likely to be of practical use are the Generalized Entropy index $E_2(y) = 0.5 * \mathrm{var}(y / \bar{y})$ and the ordinally equivalent coefficient of variation. For $E_2(y)$ it is straightforward to show $M_{kT} = \sum_i \sum_t (x_{kit} - \bar{x}_{kt}) \left((y_{it}/\bar{y}_t) - (y_{iA}/\bar{y}_A) \right) / N \sum_t \mathrm{cov}\left(x_{kt}, (y_t/\bar{y}_t) \right)$ and $v_{kT} = \sum_t \mathrm{cov}\left(x_{kt}, (y_t/\bar{y}_t) \right) / \sum_t \mathrm{cov}\left(y_t, (y_t/\bar{y}_t) \right)$. Moreover $\partial M_T / \partial e \approx \left(M_{kT} - M_T \right) v_{kT}$ if relative incomes (in relation to the mean) are not significantly affected by the change in the k'th component.

3. Empirical application

The empirical analysis is based on individual farm records from the Scottish Farm Accounts Survey (FAS) covering the production years 1995 to 2009.[3] FAS is an annual stratified sample survey of around 500 full-time farms chosen to be representative of their type and economic size as enumerated in the June Agricultural Census (Scottish Government, 2012). Table 1 presents selected results obtained using 3 separate balanced panels constructed for consecutive 5 year sub-periods. Direct payments were fully implemented by 1995 under the MacSharry reforms and decoupled in 2005 with Single Farm Payment entitlements determined using the historical approach. For each multi-year panel, probability weights were calculated using Census farm numbers in the base year, thereby abstracting from the effects of structural change. All standard errors were generated using a bootstrap procedure that reflects the panel design.[4]

---

[3] See Allanson et al. (2017) for a full account of the construction of the data set employed in the study. Comparable results reported in this study differ slightly due to differences in panel construction and definition of the weights.

[4] Lowland Sheep & Cattle farms were re-assigned to the LFA Specialist Sheep, Specialist Cattle, and Sheep & Cattle types for the bootstrap because of low numbers of observations.

Farm income was defined as the difference between trading revenues and expenditures, with this measure of cash income representing the return to the group with an entrepreneurial interest in the farm for their manual and managerial labour and on their investment in the business (Scottish Government, 2012). Average annual income over the entire period was £34,260 in nominal terms, with revenues of £117084 – £25960 in direct payments and £91124 in other 'market-based' revenues (including associated grants and subsidies) – and expenditures of –£82824.

Income mobility was 0.03 in the 1995-96 measurement period, meaning that averaging incomes over 1995 and 1996 reduced inequality by 3% compared to the weighted average of the Gini coefficients for the 2 years. M_T (the Shorrocks index of the degree of equalisation) was higher, as expected, in the longer measurement period 1995-99. Allanson et al (2017) find that M_T approaches an upper limiting value after about 10 years, with no further equalisation once relative incomes have approached their long-term values.

The reported values of the component-related mobility indices reveal that income mobility was negatively related to both direct payments and trading expenditure but was not significantly associated with market-based revenues except in the 2006-10 measurement period. As expected, the covariation shares are positive for the two revenue components and negative for expenditure. In combination, these results might be taken to imply that the 'share' of income mobility due to the association with expenditures was slightly greater than one, being partially offset by the stabilising effect of direct payments and with market-based revenues not playing a consistently significant role.

A more meaningful exercise for policy purposes is to examine the marginal effects. In the 1995-96 measurement period, an equiproportionate expansion in market-based revenue, direct payments or trading expenditure by an average absolute amount of £1000 per annum would have changed mobility by respectively –0.0008, –0.0006 and 0.0012 ceteris paribus.

Hence, higher overall levels of support would have reduced mobility compared to what it would otherwise have been, unless offset by cost increases within agriculture. But a revenue-neutral change in the balance of support measures would have had very little effect on income mobility, with this also being the case both over the 5 year measurement period and for alternative base years. The corresponding elasticities of mobility with respect to the three components were –2.4%, –0.4% and 2.8%, with little change in relative magnitudes over alternative measurement periods. The sensitivity of mobility to changes in market-based revenues and expenditure reflects the residual nature of farm income.

Construction of balanced panels longer than 5 years results in a progressive loss of coverage by farm type and size due to sample attrition. Bearing this limitation in mind, longer measurement periods − up to the full 15 years of the study period − yielded broadly similar estimates of the marginal effects. For the $E_2(y)$ inequality measure, absolute marginal effect estimates were also found to imply that mobility was decreasing in the overall level of support and invariant to changes in its balance.[5]

4. Discussion

Direct payments are generally held to have increased farm income stability (Tangermann, 2011), mainly because they are less variable than other income components (Severini *et al.*, 2016). However it need not follow that direct payments will have also reduced income mobility, which measures the movement of farms within the income distribution and therefore reflects the degree of idiosyncratic rather than overall income variability. This note makes novel use of a decomposition of the Shorrocks index by income components to show that a revenue-neutral change in the balance between market-based support and direct payments would not have reduced the variability of relative incomes in Scottish agriculture. It also adds to the existing literature on the redistributive impact of agricultural support policy, which

[5] These additional results are available from the author on request.

focuses on the effects on annual income inequality (Keeney, 2000, Allanson, 2008; Deppermann *et al.*, 2014). In particular, higher overall levels of support would likely have reduced income mobility and thereby the degree of inequality in the short-term compared to the longer term. Further studies are required to explore whether these findings are more generally characteristic of the dynamic redistributive properties of the CAP throughout the European Union.

References

Allanson, P. 'On the Characterisation and Measurement of the Redistributive Effect of Agricultural Policy', *Journal of Agricultural Economics,* Vol. 59, (2008) pp.169-187.

Allanson, P., Gerdtham, U-G. and Petrie, D. 'Longitudinal analysis of income-related health inequality', *Journal of Health Economics*, Vol. 29, (2010) pp.78-86.

Allanson, P., Kasprzyk, K. and Barnes, A. 'Income Mobility and Income Inequality in Scottish Agriculture', *Journal of Agricultural Economics,* Vol. 68(2) (2017), pp. 471–493.

Amiel, Y., Cowell, F.A. and Polovin, A. 'Inequality among the Kibbutzim', *Economica, Vol.* 63(250, Supplement) (1996), pp. S63-S85.

Deppermann, A., Grethe, H. Offermann, F. 'Distributional effects of CAP liberalisation on western German farm incomes: an ex-ante analysis', *European Review of Agricultural Economics,* Vol. 41, (2014) pp. 605–626,

European Commission, Directorate General for Agriculture and Rural Development. *CAP Health Check – Impact Assessment Note no. 8*, Subject: Risk and Crisis management. Document D(2008) NG-CF/15335, Brussels 20 May 2008.

European Commission. *Overview of CAP Reform 2014–2020*, Agricultural Policy Perspectives Brief No. 5 (European Commission, Brussels, Belgium, 2013). Available at: http://ec.europa.eu/agriculture/policy-perspectives/policy-briefs/05_en.pdf (last accessed: 9 August 2017).

Finger, R. and El Benni, N. 'A note on the effects of the Income Stabilisation Tool on income inequality in agriculture', *Journal of Agricultural Economics,* Vol. 65(3) (2014), pp. 739–745.

Jones, A. M. and López Nicolás, A. ‘Measurement and explanation of socioeconomic inequality in health with longitudinal data’, *Health Economics*, Vol.13, (2004) pp.1015-1030.

Lerman, R. J. and Yitzhaki, S. ‘Income inequality effects by income source: A new approach and applications to the U.S.’, *Review of Economics and Statistics*, Vol. 67, (1985) pp. 151–156.

Keeney, M. ‘The distributional impact of direct payments on Irish farm incomes’, *Journal of Agricultural Economics*, Vol. 51, (2000) pp.252–265.

Meuwissen M.P.M., van Asseldonk M.A.P.M., and Huirne R.B.M. (eds.). *Income stabilisation in European agriculture*. Wageningen Academic Publishers (Wageningen, The Netherlands, 2008)

Scottish Government. *Farm Income Estimates Derived from the Farm Accounts Survey for Scotland: Methodology and Quality Note* (Rural and Environment Science and Analytical Services, Edinburgh, Scotland, 2012). Available at: http://www.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubEconomicReport/methodology (last accessed: 9 August 2017).

Severini S., Tantari A. and Di Tommaso, G. ‘Do CAP direct payments stabilise farm income? Empirical evidences from a constant sample of Italian farms’, *Agricultural and Food Economics*, Vol. 4 (2016b), 6.

Shorrocks, A. F. ‘Income inequality and income mobility’, *Journal of Economic Theory*, Vol. 19, (1978) pp. 376–393.

Tangermann, S. *Risk Management in Agriculture and the Future of the EU’s Common Agricultural Policy*, ICTSD Issue Paper No. 34 (International Centre for Trade and Sustainable Development, Geneva, Switzerland, 2011). Available at: http://www.ictsd.org/research (last accessed: 9 August 2017).

Yitzhaki, S. and Schechtman, E. *The Gini methodology: A primer on a statistical methodology*. Springer (New York, USA, 2013).

Table 1. Income mobility effects by income component for selected measurement periods

Balanced panel	1995-99			2000-04	2005-09
Number of farms	*385*			*310*	*383*
Measurement period	1995 only	1995-96	1995-99	2000-04	2005-09
Base year	*1995*	*1995*	*1995*	*2000*	*2005*
T	*1*	*2*	*5*	*5*	*5*
Annual averages (£ per farm)					
Income	39489***	41350 ***	32533***	31228***	39427 ***
	1472	*1390*	*1171*	*1287*	*1372*
Market-based revenues	85984***	87906 ***	79197***	82117***	109299 ***
	3110	*2930*	*2740*	*3848*	*3347*
Direct payments	21372***	22333 ***	21596***	25115***	33034 ***
	639	*620*	*590*	*654*	*739*
Trading expenditure	–67866***	–68890 ***	–68260***	–76004***	–102906 ***
	2673	*2737*	*2716*	*3838*	*2969*
Average annual Gini: $\sum w_t G(y_t, R_t)$	0.4927***	0.4658 ***	0.4982***	0.5083***	0.5020 ***
	0.0153	*0.0133*	*0.0156*	*0.0241*	*0.0158*
T-Period Gini: $G(y_A, R_A)$	0.4927***	0.4520 ***	0.4622***	0.4479***	0.4374 ***
	0.0153	*0.0136*	*0.0158*	*0.0250*	*0.0169*
Shorrocks Mobility Index: M_T	0	0.0297 ***	0.0724***	0.1188***	0.1287 ***
	-	*0.0041*	*0.0068*	*0.0147*	*0.0130*
Component-related income mobility: M_{kT}					
Market based revenues	-	–0.0093	–0.0040	–0.0456	–0.0588 **
		0.0057	*0.0158*	*0.0324*	*0.0265*
Direct payments	-	–0.0160 **	–0.0491*	–0.1522***	–0.1633 ***
		0.0077	*0.0258*	*0.0382*	*0.0247*
Trading expenditure	-	–0.0458 ***	–0.0835***	–0.2421***	–0.2588 ***
		0.0099	*0.0285*	*0.0874*	*0.0595*
Share of total covariation: ν_{kT}					
Market based revenues	-	1.8344 ***	1.8344***	1.6766***	1.7648 ***
		0.0963	*0.1281*	*0.1725*	*0.0871*
Direct payments	-	0.2851 ***	0.2968***	0.3497***	0.3610 ***
		0.0253	*0.0332*	*0.0320*	*0.0274*
Trading expenditure	-	–1.1195 ***	–1.1312***	–1.0263***	–1.1258 ***
		0.1141	*0.1550*	*0.1906*	*0.0928*
Share of income mobility: $M_{kT}\nu_{kT} / M_T$					
Market based revenues	-	–0.5743	–0.1025	–0.6433	–0.8066 **
		0.3837	*0.3997*	*0.4341*	*0.3340*
Direct payments	-	–0.1542 **	–0.2013*	–0.4480***	–0.4581 ***
		0.0762	*0.1189*	*0.0864*	*0.0655*
Trading expenditure	-	1.7285 ***	1.3038***	2.0913***	2.2647 ***
		0.4199	*0.4965*	*0.4876*	*0.3742*
Absolute marginal effect $\times 10^3$: $(M_{kT} - M_T)\nu_{kT} / \lvert \bar{x}_{kA} \rvert$					
Market based revenues	-	–0.0008 ***	–0.0018***	–0.0034***	–0.0030 ***
		0.0002	*0.0005*	*0.0008*	*0.0005*
Direct payments	-	–0.0006 ***	–0.0017***	–0.0038***	–0.0032 ***
		0.0001	*0.0005*	*0.0007*	*0.0004*
Trading expenditure	-	0.0012 ***	0.0026***	0.0049***	0.0042 ***
		0.0002	*0.0007*	*0.0010*	*0.0006*
Relative marginal effect: $(M_{kT} - M_T)\nu_{kT} / M_T$					
Market based revenues	-	–2.4087 ***	–1.9369***	–2.3199***	–2.5714 ***
		0.4346	*0.4818*	*0.5154*	*0.3507*
Direct payments	-	–0.4393 ***	–0.4982***	–0.7978***	–0.8192 ***
		0.0860	*0.1441*	*0.1014*	*0.0825*
Trading expenditure	-	2.8480 ***	2.4350***	3.1176***	3.3905 ***
		0.4793	*0.6039*	*0.5728*	*0.3975*

*Source: Authors' calculations. Bootstrapped standard errors in italics based on 1000 replications. Statistical significance at 1%, 5% and 10% levels are denoted by ***, ** and * respectively.*